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15. Supplementary Notes

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16. Abstract (MAXIMUM 200 WORDS)

The United States Coast Guard (USCG) required data to either support a proposal to the International Maritime Organization (IMO) or to change existing policy regarding structural insulation materials. Historically, the USCG has required testing of insulation materials for use in an A-60 assembly (baseline thickness). Upon successful completion of this testing, a calculation method was applied to determine the insulation thickness required for A-30 and A-15 rated assemblies. The calculation method was that for an A-30 assembly, 75 percent of the A-60 insulation thickness was used and for an A-15 assembly, 50 percent of the A-60 insulation thickness was used.

A series of bulkhead and deck fire tests was conducted to develop the required test data to evaluate the validity of this calculation method. Each deck and bulkhead test assembly was comprised of six test samples: two baseline thickness, two 75 percent of baseline thickness, and two 50 percent of baseline thickness samples. All samples were nominally 0.9 m (3 ft) square. Comparison of the test results with calculated times to exceed the temperature limits using the underlying heat transfer principles indicated that the calculation method is adequate. Heat transfer modeling of the tested assemblies was conducted to numerically reduce the thickness of each insulation material to fit as closely as possible, the appropriate 60, 30, and 15 minutes of fire resistance requirements. Analysis of the reduced thicknesses using the basic heat transfer principles has determined that the calculation method is adequate.

17. Key Words	18. Distribution Statement
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EXECUTIVE SUMMARY

Structural insulations are used to provide fire resistance properties to structural members (i.e., decks and bulkheads) so they will form barriers to prevent the spread of a fire. Historically, the U. S. Coast Guard (USCG) has required testing of insulation materials at the thickness needed for use in an A-60 assembly. Upon successful completion of this testing, a calculation method was applied to determine the insulation thickness required for A-30 and A-15 rated assemblies. The calculation method was that for an A-30 assembly, 75 percent of the A-60 insulation thickness can be used, and for an A-15 assembly, 50 percent of the A-60 insulation thickness can be used.

"A" class divisions are defined as divisions formed by suitably stiffened bulkheads and decks which are constructed of steel or other equivalent materials and are constructed so as to be capable of preventing the passage of smoke and flame for a minimum one-hour period. Specific bulkheads and decks are required to be insulated with an approved non-combustible material which will limit the average temperature rise on the unexposed side to no more than 140 ºC (250 ºF) above the original temperature. The insulation is also required to limit the temperature at any one point, including any joint, to no more than 180 ºC (325 ºF) above the original temperature. The insulated assemblies are required to demonstrate these characteristics for the following times: a class "A-60" for a minimum of 60 minutes, a class "A-30" for a minimum of 30 minutes, and a class "A-15" for a minimum of 15 minutes.

The calculation method for insulation thicknesses has its basis in the basic heat conduction equations. The concept was proposed to the International Maritime Organization (IMO) but it was not accepted because it appears that the test data to support this calculation method was not available. In order to proceed with the proposal to IMO, the necessary supporting data had to be generated.

Recent changes to the method of testing bulkheads and decks have been formalized in the International Code for Application of Fire Test Procedures (FTP Code).

The FTP Code changed how the insulations were tested and greatly increased the number of required tests beyond what the USCG has required before.

The USCG needed to develop data to verify the calculation method under the International Code for Application of Fire Test Procedures (FTP Code) and provide the data in support for a proposal to IMO. To develop data specific to the testing of structural materials, four insulation materials (three batt/blanket type materials and one spray-applied fiber material) were installed on small-scale deck and bulkhead test samples. Each insulation material was applied to the test samples at the USCG approved baseline thickness. The calculation method was then applied to determine the reduced thicknesses needed for A-30 and A-15 divisions. Four bulkhead tests (vertical tests) and four deck tests (horizontal tests) were conducted for a total of eight tests. Each deck and bulkhead test assembly was comprised of six small-scale insulated test samples, each nominally 0.91 x 0.91 m (3 ft x 3 ft) in size and did not contain stiffeners. Each bulkhead and deck assembly included duplicate test samples of A-60, A-30 and A-15 insulation. By testing the three variations simultaneously, possible furnace control factors were eliminated from the test series. For the bulkhead tests, the uninsulated side of the small-scale assemblies was exposed to the fire (i.e., insulation on the unexposed face). In the deck tests, the insulated side was exposed to the fire. All testing was conducted in general accordance with Part 3 – Tests for "A," "B," and "F" Class Divisions of Annex 1 (Fire Test Procedures) of the FTP Code.

The results of the fire tests indicated that for bulkhead insulation materials tested at a thickness corresponding to 50 percent of the baseline thickness (i.e., expected to provide a minimum of 15 minutes of fire resistance), the average time to exceed the temperature limits was 24 ±6 minutes. For deck insulation materials, the average time to exceed the A-15 temperature limits was 44 ± 4 minutes. Bulkhead insulation materials tested at a thickness corresponding to 75 percent of the baseline thickness (i.e., expected to provide a minimum of 30 minutes of fire resistance) averaged a time to exceed the temperature limits of 44 ± 4 minutes. For the deck insulation materials, the average time to exceed the A-30 temperature limits was 56 ± 7 minutes. This indicated that application of the calculation method was adequate and conservative. Some A-60

thicknesses may pass the FTP Code tests with varying degrees of conservatism. For example, one manufacturer's insulation may pass the test at 62 minutes while another may pass at 69 minutes. In order to address the inherent conservatism due to the insulation thickness, an effort was undertaken using a finite difference heat transfer model to "optimize" the insulation thickness, based on the test results.

A one-dimensional heat transfer analysis was performed to calculate the unexposed surface temperature for each insulation sample. This analysis involved modeling the time-dependent temperature response of the insulation/steel sample to a thermal insult provided by the furnace (i.e., IMO time/temperature curve). The heat transfer model was initially calibrated using the baseline insulation thickness test data. Once an adequate simulation was achieved, the insulation thickness was modified to correspond to the testing thicknesses and the new time-dependent temperature calculated. No other model parameters were changed.

Examination of the predicted times to failure compared to the tested times to failure indicated that the computer model was capable of closely predicting the heat transfer through the insulation material. Adjustments to the insulation thickness were performed to achieve a balance between the insulation thickness and the predicted time to exceed the temperature limits. The goal of this part of the modeling effort was to determine the appropriate insulation thickness required to provide 15 minutes, 30 minutes, and 60 minutes of fire resistance. Application of the calculation method to the baseline 60 minutes insulation thickness (and assuming this value was a constant), the 50 percent and 75 percent insulation thickness were calculated. The calculated calculation method insulation thicknesses were within 10 mm (0.4 inch) of the "optimized" 50 percent and 75 percent of baseline insulation thicknesses, indicating that the calculation method remains adequate. The developed data shows that the current calculation method adequately predicts 50 percent and 75 percent of baseline insulation thickness, given an approved baseline insulation thickness and does not require any adjustment.